

12-15-1984

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## Recommended Citation

Schmiesing, Brian; Blank, Steven; and Gunn, Steven, "The Influence of Technological Change on Grain Elevator Pricing Efficiency" (1984). *Department of Economics Staff Paper Series*. Paper 26.  
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THE INFLUENCE OF TECHNOLOGICAL CHANGE ON  
GRAIN ELEVATOR PRICING EFFICIENCY\*

by

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Economics Staff Paper No. 84-11\*\*\*  
December 1984

\*Chuck Lamberton and Gene Murra made many comments on this paper which improved the quality and presentation of the report. However, the authors are solely responsible for any remaining errors or omissions.

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ABSTRACT

The introduction of unit train technology is found to increase the pricing efficiency of a case study elevator. Daily prices are found to be more correlated with destination market prices and nearby futures contract prices after the subterminal was introduced. The increased ability to physically arbitrage between markets integrated the elevator into the regional and national grain market. The subterminal technology altered the price behavior of the elevator beyond simply changing the level of prices received by producers.



## THE INFLUENCE OF TECHNOLOGICAL CHANGE ON GRAIN ELEVATOR PRICING EFFICIENCY

Technological innovation can cause major changes both in how organizations react to their environment and in the nature of their internal business operations (10). The trend of subterminal elevators using unit trains to market to major terminal and export outlets is one example of the impact technology is having on agricultural markets.

The introduction of unit train technology causes fundamental changes in the way an elevator merchandises its grain. The elevator has access to larger and more distant markets. Therefore, its ability to arbitrage between markets increases. As a result, elevator managers need new methods to protect against adverse price movements on grain inventories held. Closer linkages between cash and futures markets would be expected. The elevator must attract a larger volume of grain, which requires more aggressive pricing by the elevator. Therefore, the elevator would be expected to become more responsive to price changes at the major regional terminal markets.

South Dakota only recently has experienced rapid expansion of subterminals and unit train rates. During the early 1970's a majority of rail lines were unable to safely use the 100-ton hopper cars. By 1980, railroad abandonment had reached a crisis level in South Dakota with 1,089 miles of rail line being left idle. In response to this transportation crisis, the South Dakota legislature established the South Dakota Railroad Authority to purchase railroad properties from private railroad companies. After the purchase of a core system of railroad trackage by the Authority, the Burlington Northern was given operating rights to the core system. Unit train rates were introduced by the Burlington Northern in the fall of 1981. Rehabilitation of the purchased railroad lines continued through 1983 (13).

The effects that introducing unit train technology have had on prices received by producers are of great concern when attempting to judge the value of that market innovation. Therefore, an economic evaluation of those effects is needed. As a contribution to that effort, pricing impacts at a local market were examined in this study.

The general objective of the study was to evaluate the impact of unit train technology implementation on patterns and levels of prices paid to producers. Three specific objectives follow:

1. Establish whether introducing unit train technology led to changes in price relationships between a local South Dakota elevator and major grain markets outside the state.
2. Determine whether introducing unit trains led to changes in the local elevator's pricing efficiency.
3. Identify any evidence of more aggressive pricing by the local elevator after the unit train facility began operating.

#### General Methodology

The influence of technological change on pricing performance and arbitrage was evaluated by conducting an experiment using data from an isolated South Dakota market. Daily corn price data were collected for a two year period, one year before and one year after introduction of a unit train facility at a local elevator. Comparable data were collected for major regional and export markets for the same period.

The data were used in a "single group with continuous single treatment" time-series design experiment, diagrammed below:

$$O_{t-n}, \dots, O_{t-2}, O_{t-1}, X_{t+1}, X_{t+2}, \dots, X_{t+n}.$$



An "O" identifies a measurement or observation event and an "X" represents the introduction of an experimental stimulus to a group. The price data from all cash markets were used to examine the price relationships between markets before and after introduction of the unit train. The lack of water transportation and other competitive subterminals in the elevator's trade region at that time provided a unique opportunity to analyze the technology's impact on the pricing behavior of an elevator without statistical interdependencies. Also, the price responsiveness to changes in near-by futures contracts was tested. Finally, relative price relationships between the cash markets were examined for evidence of changes in the local elevator's pricing behavior.

The unique characteristics of the local South Dakota market lead to a natural experiment with good internal and external validity. Although considered a "quasi-experiment" (1, p. 200), the time series design deals adequately in this case with most sources of experimental error. During the "before" period a very limited number of unit train facilities existed in South Dakota. After the policy decision concerning the core railroad system, use of unit trains by grain merchandisers increased rapidly. Blanket unit train rates led to uniform pricing for unit train service state-wide. Therefore, any impact of unit trains will be clearly visible in the data. This experimental approach is a strong alternative to other methodologies used to analyze the pricing impact of technological change.

Cross sectional studies have incorporated the subterminal technology into their analysis of price behavior of elevators (4, 6). The conceptual base of those analyses was a "with-and-without" criteria. They looked at how subterminal price behavior differed from that of an elevator which was not a subterminal. Davis and Hill found elevators having access to distant markets and which shipped grain by water offered higher prices to producers. Also, elevators which sold only to local markets and which lacked hedging activities



paid lower prices to producers (4). Garcia found price changes in the nearby futures markets to be instantaneously reflected (within one day) in the price changes of the majority of elevators. Models used to explain the differences in price patterns between elevators did not perform as well as desired. However, evidence did exist that elevator competition and availability of information had a positive impact on how quickly elevator prices changed in response to the futures markets (6).

The local elevator analyzed here specialized in merchandising feed to local producers and trucking corn to regional terminal markets. The elevator's immediate trade region lacked unit rates and facilities until the first months of 1982. A unit train facility began operating 10 miles east of the case study elevator at that time. The elevator began operating its subterminal in October of 1982.

After October 1982, the trade region had two subterminal elevators competing. In a study of the western New York market, Riggins found that competitive pressures were necessary for insuring responsive prices at the producer level (17). Competitive pressures between the two subterminals would result in the technology's impact being fully reflected in prices paid to producers. This was probably not the case when only one subterminal existed in the region.

#### Expected Changes in Pricing Efficiency

Pricing efficiency refers to the ability of the vertical grain marketing channel to coordinate the flow of physical commodity from producer to consumer. This concept of pricing efficiency was utilized by Thompson and Dahl when they analyzed the efficiency of the grain export market (19). Coordination between stages must be high if the level of pricing efficiency is going to be high. Cash and futures prices play a major role in coordinating the grain marketing system (16, pp. 9-10).



An efficient pricing system will enable efficient price arbitrage between markets. The spatial equilibrium price surface must be enforced by the physical arbitrage process. Unit trains improve the ability to arbitrage within and among the various stages in the grain marketing channel. Improved ability to physically arbitrage implies that prices among the various stages in the market channel will become more correlated. Major market cash and futures prices would have increased ability to coordinate the movement of grain from the producer to the destination markets because they would become relevant signals in a larger number of local markets.

The introduction of subterminal technology would be expected to impact on price efficiency and behavior of the local elevator. The elevator would have to expand its trade area or increase its price competitiveness to obtain the necessary grain volume to operate the facility (2). The elevator would have to bid corn away from the regional terminal markets and competing local firms. The expectation would be for elevator prices to more closely follow the prices of regional terminal markets such as Minneapolis.

The introduction of subterminal technology also would be expected to increase the strength of the price linkage between the elevator and port-of-exit markets in Portland and the Gulf. Corn now is shipped directly to these markets rather than through regional terminal markets. Local prices should be more reflective of the general price level and daily price changes in the export markets.

Due to the larger volume accumulated by subterminal elevators, increased price correlation with futures markets would be expected. Smaller elevators can handle their inventory price risk by forward contracting with terminal elevators and immediate sale of the grain. Since subterminal elevators must accumulate large corn inventories, the expectation would be for subterminal elevators to increase their use of hedging on futures markets. Therefore,



prices at the subterminal market are expected to be more sensitive to futures market price changes. Helmuth found subterminal elevators to hedge more routinely than country elevators (7, p. 19).

Destination grain price quotes often are in terms of the nearby futures contract. The increased dependence on destination markets rather than local merchandising outlets would also increase the price responsiveness to price changes in the futures market.

Price relationships at the local elevator are expected to change in three basic ways. 1 - The absolute price level of the local market would become more correlated with the destination markets. 2 - Daily price changes of the local market would be more correlated with daily price changes at the destination markets. 3 - Daily price changes of the local market would be more correlated with changes in the nearby futures contracts. Three models were developed to test these hypotheses.

#### Absolute Price Model

Local elevators merchandising corn to destination markets will respond to price changes at those markets. Individually, local elevators contribute a small portion of the total grain merchandised at the destination market. As a result, local elevator prices are expected to follow the destination markets rather than the reverse. Grain buyers at export terminals do not call local subterminal elevators or use local farm prices to establish their price. Therefore, the local subterminal's daily corn price,  $P_s$ , was specified as being a function of the destination market's daily corn price,  $P_d$ .

$$(1) \quad P_s = \alpha + \beta P_d + \epsilon$$

Absolute price relationships were analyzed using model (1). It considers whether local elevator prices move with changes in the price level at destination markets.<sup>1</sup>

If prices are being arbitrated effectively between markets,  $\beta = 1$ . Only if  $\beta = 1$  can it be inferred that " $\alpha$ " represents the transfer costs between the local elevator and destination markets. For  $\beta$  less than or greater than one, prices at the local elevator do not always directly follow the general price level at the destination market. Local supply and demand conditions or transportation cost changes could result in the local elevator not responding precisely to the prices at the destination markets. Methods used by elevator operators to treat handling and/or carrying cost differences, plus different levels of efficiency between markets, cause  $\beta$  not to equal one. Also, if another destination market becomes dominant in the region, local elevator prices could follow that destination market. The  $\beta$  indicates the local responsiveness to changes in price levels at the destination markets. The closer the  $\beta$  is to one, the more closely the local elevator followed the destination market's general price level.

#### Daily Cash Price Change Model

The daily cash price change models below was used to measure the relative price responsiveness of the local market to price changes in destination markets. All price changes of specific size were grouped and independent of the absolute price level in the markets. The daily price change in the local elevator,  $Pds$ , was specified as being a function of the destination market's daily price change,  $Pdd$ .

$$(2) \quad Pds_t = \alpha + \beta Pdd_t + \epsilon \quad \text{where } Pds_t = (Ps_t - Ps_{t-1})$$

$$Pdd_t = (Pd_t - Pd_{t-1})$$

The interpretation of the coefficients in (2) differs from that of the previous model. It is expected that  $\alpha = 0$ . If the destination price does not change, the local market price would not be expected to change. Also, if  $\alpha > 0$ , this implies the value of the local price changes is greater for price increases in destination markets than for price decreases. If  $\alpha < 0$ , the opposite would be true.



The slope coefficient measures correlation of the local market price changes with daily price changes in the destination market. If  $\beta = 1$ , the daily price change between the markets is identical except for random error. If  $\beta = 0$ , there appears to be no linkage between the two markets. The stronger the linkage between the markets, the closer  $\beta$  will be to one.

Model (2) can be rewritten to facilitate interpretation. Within one period (either before or after the technological change), assuming that  $\alpha = 0$  and a positive price change at the destination market, the model is

$$P_{s_t} - P_{s_{t-1}} = \beta P_{d_t} - \beta P_{d_{t-1}} \quad \text{or}$$

$$(\beta P_{d_{t-1}} - P_{d_{t-1}}) + (P_{d_{t-1}} - P_{s_{t-1}}) = (\beta P_{d_t} - P_{d_t}) + (P_{d_t} - P_{s_t}).$$

$$\text{Then, } (P_{d_t} - P_{s_t}) = (P_{d_{t-1}} - P_{s_{t-1}}) - (\beta - 1)(P_{d_t} - P_{d_{t-1}}).$$

If  $\beta = 1$ , the intermarket price differential does not change from time  $t-1$  to  $t$  since  $(P_{d_t} - P_{s_t}) = (P_{d_{t-1}} - P_{s_{t-1}})$ . If  $\beta < 1$ , the intermarket price differential increases from time  $t-1$  to  $t$ . On the other hand, if  $\beta > 1$ , the intermarket price differential narrows from time  $t-1$  to  $t$  implying that the new technology resulted in efficiency gains lowering costs of moving corn from origin to destination markets.

More generally, for all values of  $\alpha$ , the model is

$$(P_{d_t} - P_{s_t}) = (P_{d_{t-1}} - P_{s_{t-1}}) - (\beta - 1)(P_{d_t} - P_{d_{t-1}}) - \alpha.$$

In this case if  $\beta = 1$ ,  $\alpha > 0$  implies that the intermarket price differential has narrowed. If  $\beta = 1$ ,  $\alpha < 0$  implies a wider differential between markets. When  $\beta \neq 1$  and  $\alpha \neq 0$ , it is implied that the price differential has narrowed or widened as  $[(\beta - 1)(P_{d_t} - P_{d_{t-1}}) + \alpha] < 0$ . The coefficients are interrelated. However, this can be associated with the absolute price model; e.g., if there is no change in destination price between times  $t-1$  and  $t$ , then  $(\beta - 1)(P_{d_t} - P_{d_{t-1}}) = 0$  and the intermarket price differential has narrowed or widened from time  $t-1$  to  $t$  as  $\alpha > 0$ .

### Futures Market Price Change Model

The local elevator is expected to have been more responsive to futures market price changes after the unit train technology was introduced. Similar to the daily cash price change model, all price changes of the independent variable are independent of the absolute price level in the futures market. Unlike the daily cash price model, the local elevator and destination prices are correlated with the nearby futures contract price changes. The daily price change in the local cash market,  $Pdc_t$ , is specified as being a function of the nearby futures price change,  $Pdf_t$ .

$$(3) \quad Pdc_t = \alpha + \beta Pdf_t + \varepsilon \quad \text{where } Pdc_t = (Pc_t - Pc_{t-1})$$

$$Pdf_t = (Pf_t - Pf_{t-1})$$

It is expected that  $\alpha = 0$ , since it is expected that there will be no change in the cash market price when there is no change in the nearby futures market price. Again, the closer the slope coefficient is to one, the stronger the price relationship between cash and nearby futures market price changes. The discussion above concerning the implications for model (2) of differing values for  $\beta$  and  $\alpha$  applies also to model (3).

The specification of model (3) implies that local cash prices are a function of futures prices. When elevators are merchandising grain, prices often are expressed in terms of the basis. Model (3) states that if the basis does not change, price movement in the futures market will be transferred throughout the grain marketing channel in the form of local price changes. Hedging activities of the local elevator imply that their price will be a direct function of futures prices and the basis. Changes in the basis and the extent of elevator hedging will affect how much of the futures market price changes would actually be reflected in the elevator's prices.

The causal link between futures and local cash prices, described above, has not been subject to extensive evaluation. Standard cash-futures price theory specifies futures as a function of cash prices. For a storable commodity,



futures prices are expected to reflect cash prices anticipated at the time of contract delivery. The one-market-one-price theory describes futures prices for contracts expiring within the current marketing year as simply the current cash price adjusted for storage costs (subject to the expected supply of and demand for storage space) (8). This implies that the proposed price relationship,

$$\text{Cash}_{\text{Dest.}} \rightarrow \text{Futures} \rightarrow \text{Cash}_{\text{Local}}$$

may be spurious. The  $F \rightarrow C_{\text{Local}}$  relationship being tested may indirectly reflect part of the expected  $C_{\text{Dest.}} \rightarrow C_{\text{Local}}$  causality. However, some empirical data have been collected which supports this relationship (3, 7, 9). Therefore, only one part of the model is evaluated here. The complete causal relationship expected is diagrammed below.

$$\begin{array}{ccc} \text{Cash}_{\text{Dest.}} & \rightarrow & \text{Futures} \\ & \searrow & \downarrow \\ & & \text{Cash}_{\text{Local}} \end{array}$$

This model incorporates the fact that local elevators are price takers in their hedging activities. Of the three relationships diagrammed, the  $C_{\text{Dest.}} \rightarrow F$  connection has been tested thoroughly by numerous studies, the  $C_{\text{Dest.}} \rightarrow C_{\text{Local}}$  portion is estimated here using equation (2), and  $F \rightarrow C_{\text{Local}}$  is estimated using equation (3). The impacts of destination cash and futures prices on local cash prices could not be estimated together in a single multiple regression equation due to multicollinearity between  $C_{\text{Dest.}}$  and  $F$ .

#### Data Used in Analysis

Daily prices were collected for No. 2 corn for the South Dakota subterminal market, two port-of-exit markets, two intermediate markets, and nearby futures contracts. These prices were collected for the period of October 1, 1981 through September 30, 1983. The analysis was broken into two periods based on the opening of the subterminal at the local elevator in October 1982. The No. 2 cash corn prices used are those posted after the close of the futures

market each day. Closing prices on the Chicago Board of Trade corn futures contract also were used in the analysis.

The two port-of-exit markets selected were the Gulf and Portland. The Pacific Northwest has become a major corn export market for South Dakota (12). South Dakota corn also has been marketed to the Gulf directly or through an intermediate market.

The two intermediate markets selected were Minneapolis and Chicago. Minneapolis represents a major intermediate terminal for the transportation of corn on the Mississippi River and represents a major regional market for corn (5, 14). Although South Dakota corn is not shipped directly to Chicago, a positive correlation between the two cash market prices would be expected. Chicago is a delivery point for the futures market, and therefore, is linked to the South Dakota market through hedging activities of elevators.

Nearby futures prices are defined as the closing prices for the corn futures contract closest to maturity. After the last trading day of the month prior to the delivery month, the succeeding futures contract's closing price replaces the previous contract's closing price. For example, during August of 1982, the September 1982 futures contract was used until the last trading day in August. On the first trading day in September, the December 1982 contract replaced the September contract.

#### Absolute Price Model Results

Statistically significant first order autocorrelation existed in all the ordinary least squares estimates of the absolute price change model. Therefore, Yule-Walker equations were used to estimate the level of the first order autocorrelation (15). The estimated first order autocorrelations were then used to estimate generalized least squares models of the absolute price series (11). As explained by Kennedy (11, p. 90), the transformation of all



variables used in obtaining the GLS estimates is derived as follows. The equation to be estimated is

$$y_t = \alpha + \beta X_t + \varepsilon_t \quad \text{where } \varepsilon_t = \rho \varepsilon_{t-1} + u_t.$$

Lagging and multiplying by  $\rho$  gives

$$\rho y_{t-1} = \rho \alpha + \rho \beta X_{t-1} + \rho \varepsilon_{t-1}.$$

Subtracting this second equation from the first gives

$$y_t - \rho y_{t-1} = \alpha(1-\rho) + \beta(X_t - \rho X_{t-1}) + (\varepsilon_t - \rho \varepsilon_{t-1})$$

or

$$y_t^* = \alpha^* + \beta X_t^* + u_t \quad \text{where "*" denotes the transformed variable. The results}$$

of the generalized least squares estimation are presented in Table 1.

After unit trains were introduced, the local South Dakota elevator experienced a major improvement in the correlation of its absolute price levels with those in the destination markets. Shifting from local merchandising to supplying major destination markets (out of competitive necessity) appeared to improve the elevator's ability to arbitrage between various markets. Changes in the absolute price levels at the destination markets were being more closely reflected in the local market. The elevator had become sensitive to the regional market of Minneapolis, in particular. If the absolute price level increased by 1 cent in Minneapolis, nine-tenths of the increase was reflected in the local elevator's prices.

The generalized least squares estimation for the second period reflected improved estimation statistics. For each of the four markets tested there was a significant increase in the degree of correlation between prices after the unit train was introduced. The increased correlation observed between the local price and each export market, despite increased variation in price levels,<sup>2</sup> is evidence of more aggressive pricing by the elevator. That behavior caused the elevator to improve its pricing efficiency.

TABLE 1. GENERALIZED LEAST SQUARES MODEL OF DAILY NO. 2 CORN PRICES FOR SOUTH DAKOTA CASH MARKET AND SELECTED CASH MARKETS DURING OCTOBER 1, 1981 THROUGH SEPTEMBER 30, 1983.<sup>a</sup>

Generalized Least Squares Model	F-Test	Number of Observations	Durbin-Watson Statistic	Adjusted R <sup>2</sup>
PRE-SUBTERMINAL PERIOD: OCTOBER 1, 1981 - SEPTEMBER 30, 1982 <sup>b</sup>				
S.D. = 12.75 + .11* Gulf (.56) (.03)	14.7	249	1.22	.05
S.D. = 15.57 + .29* Portland (1.40) (.03)	78.9	249	1.30	.24
S.D. = 8.38 + .29* Chicago (.36) (.03)	12.4	249	1.38	.04
S.D. = 13.35 + .19* Minneapolis (.36) (.03)	28.1	249	1.27	.10
SUBTERMINAL PERIOD: OCTOBER 1, 1982 - SEPTEMBER 30, 1983 <sup>b</sup>				
S.D. = - 2.47 + .85* Gulf (.56) (.03)	1317.7	249	2.13	.84
S.D. = - 7.47 + .81* Portland (1.40) (.03)	927.9	249	2.14	.79
S.D. = .84 + .84* Chicago (.95) (.02)	1428.1	249	1.97	.85
S.D. = .56 + .90* Minneapolis (1.13) (.02)	2697.7	249	1.94	.92

<sup>a</sup>Dependent and independent variables were expressed in terms of cents per bushel.

<sup>b</sup>Standard errors of the coefficients are presented in the parentheses. A "\*" indicates that  $\beta$  was significantly different from one at the five percent level.



This case study may overstate the potential improvement in price performance resulting from the introduction of the subterminal technology due to South Dakota's railroad transportation difficulties and the delayed introduction of unit train rates (18). However, the data clearly support the contention that introduction of this technology has resulted in greater price efficiency in local corn markets. Absolute price changes in export markets were reflected in the South Dakota market. There appeared to be an improvement in the ability of the local South Dakota cash market to arbitrage between export cash markets. The speed of the arbitrage process was partially reflected in the daily price change analysis discussed in the next section.

#### Daily Cash Price Change Model Results

An ordinary least squares estimation was used for the daily cash price change models (see Table 2) because there was no statistically significant first order autocorrelation at the 5 percent level.

The elevator's inability to arbitrage during the pre-subterminal period was reflected in the results. Daily price changes in the local cash market were not strongly correlated with the export cash markets. Because the local elevator markets its corn to intermediaries, the prices it receives may not reflect all price fluctuation of destination markets.

After unit trains were introduced, the elevator became more responsive to price changes in the export markets. The correlation was highest between South Dakota and the closest destination markets: Chicago and Minneapolis. This would be expected in an efficient market. The relationship between price changes for each of the four destination markets and those of the local South Dakota market became stronger during the second period, as indicated by the joint-test F-statistic. In each case, however,  $\alpha$  was not significantly different than zero while  $\beta$  was different than one. Therefore, the local market was more efficient during the second period, but further improvements in efficiency may be possible.

TABLE 2. ORDINARY LEAST SQUARES MODEL OF DAILY CORN PRICE CHANGES BETWEEN THE SOUTH DAKOTA CASH MARKET AND SELECTED CASH MARKETS DURING OCTOBER 1, 1981 THROUGH SEPTEMBER 30, 1983.<sup>a</sup>

Ordinary Least Squares Model	F-Test	Number of Observations	Durbin-Watson Statistic	Adjusted R <sup>2</sup>
PRE-SUBTERMINAL PERIOD: OCTOBER 1, 1981 - SEPTEMBER 30, 1982 <sup>b</sup>				
S.D. = - .05 + .05* Gulf ( .10) (.03)	3.1	249	2.02	.01
S.D. = - .05 + .07* Portland ( .10) (.03)	6.0	249	2.05	.02
S.D. = - .05 + .07* Chicago ( .10) (.03)	4.4	249	2.07	.01
S.D. = - .05 + .08* Minneapolis ( .10) (.03)	6.2	249	2.30	.02
SUBTERMINAL PERIOD: OCTOBER 1, 1982 - SEPTEMBER 30, 1983 <sup>b</sup>				
S.D. = .19 + .42* Gulf ( .20) (.04)	93.5	249	2.05	.27
S.D. = .31 + .30* Portland ( .21) (.05)	33.6	249	1.55	.12
S.D. = .04 + .63* Chicago ( .18) (.05)	173.9	249	2.02	.41
S.D. = .16 + .53* Minneapolis ( .18) (.04)	145.7	249	2.09	.37

<sup>a</sup>Dependent and independent variables were expressed in terms of cents per bushel.

<sup>b</sup>Standard errors of the coefficients are presented in the parentheses. A "\*" indicates that  $\alpha$  was significantly different from zero or  $\beta$  was significantly different from one at the five percent level.



### Futures Market Price Change Model Results

The futures price change model was estimated for all five cash markets, not just South Dakota, to allow comparison between markets. Daily price changes were calculated for the selected cash markets and nearby futures contracts.<sup>3</sup>

Again, a major increase in the correlation between prices of the local elevator and destination markets was evident in the results for the second period (Table 3). The intercept term was not significantly different from zero, while the slope coefficient was different than one. The significance of the joint-test F-statistic increased greatly from the first period to the second.

Although all of the markets evaluated had intercept terms not significantly different from zero, only Minneapolis and the Gulf had slope coefficients not significantly different than one in both time periods. Those markets are highly correlated with the price changes in the nearby futures markets.

The decline of the correlation between the daily price changes of the nearby futures contract and the Portland corn prices raises issues concerning market structure. An analysis of Portland prices since October 1978 revealed a steady decline in correlation between that price series and nearby futures prices. Apparently, the Pacific Northwest represents a distinctly different spatial market than the Gulf. Economic factors affecting the determination of daily price changes in the Northwest spatial market are not expected to be identical to those affecting the Gulf and associated markets. This empirical result points out the need for analysis of the implications of the Pacific Northwest becoming a major port-of-exit.

### General Experiment Results

A before-after experiment was used to test the general hypothesis that implementation of unit train technology caused changes in price relationships between a local elevator and major destination markets. As described earlier, the time-series design tested whether or not there was a significant difference

TABLE 3. ORDINARY LEAST SQUARES MODEL OF DAILY CORN PRICE CHANGES BETWEEN THE SELECTED CASH MARKET AND NEARBY FUTURES CONTRACT DURING OCTOBER 1, 1981 THROUGH SEPTEMBER 30, 1983.<sup>a</sup>

Ordinary Least Squares Model	F-Test	Number of Observations	Durbin-Watson Statistic	Adjusted R <sup>2</sup>
PRE-SUBTERMINAL PERIOD: OCTOBER 1, 1981 - SEPTEMBER 30, 1982 <sup>b</sup>				
S.D. = - .04 + .11* Pdf ( .17) (.05)	6.0	238	1.81	.02
Portland = .26 + .78* Pdf ( .18) (.08)	97.2	238	2.05	.29
Gulf = .23 + .93 Pdf ( .20) (.09)	116.7	238	2.10	.33
Chicago = .13 + .80* Pdf ( .13) (.04)	114.7	237	1.97	.32
Minneapolis = .23 + .90 Pdf ( .14) (.06)	220.6	238	2.07	.48
SUBTERMINAL PERIOD: OCTOBER 1, 1982 - SEPTEMBER 30, 1983 <sup>b</sup>				
S.D. = .06 + .69* Pdf ( .17) (.05)	214.6	237	2.04	.47
Portland = .06 + .57* Pdf ( .24) (.07)	71.1	237	2.02	.23
Gulf = .22 + .93 Pdf ( .20) (.05)	294.3	237	2.08	.55
Chicago = .13 + .86* Pdf ( .13) (.04)	593.8	237	1.97	.71
Minneapolis = .16 + .96 Pdf ( .18) (.04)	529.0	237	2.03	.69

<sup>a</sup>Dependent and independent variables were expressed in terms of cents per bushel.

<sup>b</sup>Standard errors of the coefficients are presented in the parentheses. A "\*" indicates that  $\alpha$  was significantly different from zero or  $\beta$  was significantly different from one at the five percent level.



between price observations from two periods: one before and one after unit trains began operating in a South Dakota market. The statistical results are presented in Table 4.

Clearly, the experimental results support the conclusion that the relationship between prices at the local South Dakota market and each of the four destination markets changed after the technological innovation. Two tests were used to evaluate each equation discussed in the three previous sections (presented in Tables 1-3) in order to provide greater depth to the analysis. As shown in Table 4, a t-test and Chow test were conducted for each model/market combination. In every case, there was a significant difference in the price relationship between the South Dakota elevator and the export markets from one period to the next. Also, the results for the futures price change equations support the belief that over the entire period, only the South Dakota data reflect the influence of the local market innovation -- no significant change was observed in other markets.

### Conclusions

The overall objective of the paper was to establish the impact of the introduction of subterminal technology on a local elevator's pricing of corn. The analysis demonstrated that the subterminal technology caused improvements in the pricing efficiency of the elevator. The local elevator's corn prices became more correlated with both the price level and daily price changes at destination cash markets. Also, the local elevator's corn prices became more correlated with daily price changes in the nearby futures contracts. Apparently, the technological innovation integrated the elevator's pricing into the national and regional markets.

Integration of the elevator's pricing into national and regional markets has definite implications for producer marketing. Increased sensitivity to futures market price changes implies that producers must increase their under-

TABLE 4. TESTS OF DIFFERENCES BETWEEN PERIODS

Model/Markets	t-test <sup>a</sup> ( $\beta_1 = \beta_2$ )	Chow test <sup>b</sup>
Absolute price levels	(GLS equations)	
SD -- Minneapolis	35.50	*
SD -- Chicago	27.50	*
SD -- Gulf	24.66	*
SD -- Portland	17.33	*
Cash price change	(OLS equations)	
SD -- Minneapolis	11.25	27.4
SD -- Chicago	11.20	46.0
SD -- Gulf	9.25	23.5
SD -- Portland	4.60	7.3
Futures price change	(OLS equations)	
SD -- futures	11.60	32.5
Minneapolis -- futures	1.50	1.1
Chicago -- futures	1.50	0.4
Gulf -- futures	0.00	0.1
Portland -- futures	-3.00	1.8

<sup>a</sup>The significant values at the one and five percent confidence levels are, respectively, 2.58 and 1.96.

<sup>b</sup>The significant values at the one and five percent confidence levels are, respectively, 4.6 and 3.0.

\* Chow tests could not be calculated due to the influence of the data transformations required for GLS estimation. The three transformations (one for each period and one for the entire data set) did not constrain the rho values to be equal. Therefore, the transformed variables were "different" in that they had different sums of squared errors. In this case, the F-test statistics were negative. Since a Chow test based on the F-distribution will only have asymptotic validity (11, 15), it was inappropriate to use with this model.



standing of futures markets if they are going to market their grain effectively. Also, producer attention must shift from local supply and demand conditions to understanding the supply and demand conditions affecting regional and export markets.

Since subterminals increase the ability to arbitrage between markets and increase the number of available outlets, the market power of local grain buyers declines. Competitive pressures between subterminal elevators also will decrease elevator market power in local markets which, in turn, stimulates more aggressive pricing behavior on the part of local operators. Subterminal elevators appear to contribute positively to the existence of competitive markets within the grain industry.

## FOOTNOTES

1. A weakness in the model is the lack of adjustment for changes in transportation costs and merchandising margins. Changes in destination prices cannot be used to explain South Dakota price changes caused by those and other variables.
2. Before the subterminal operation, the local elevator's prices changed infrequently. After the operation of the subterminal began, prices changed with much greater frequency. The variance in prices at the local market increased during the second period, as it did in all markets tested. Even though all markets had a higher mean price that year, the coefficient of variation increased for each location.
3. One adjustment had to be made to the data base used in the analysis. The price differences between the last day that a particular futures contract was used and the first day that the next contract was used were deleted. These price differences were observed to be as large as twenty-five cents. This was not a realistic price change since the daily change is limited to ten cents for the Chicago corn futures contract. The data did not have evidence of first order autocorrelation, therefore excluding these observations would not adversely impact on the accuracy of the estimation procedures.



## REFERENCES

1. Blank, Steven. Practical Business Research Methods, Westport, Connecticut: AVI Publishing Company, 1984.
2. Chase, Craig A. and Helgeson, Delmer L. Cost Analysis of Potential North Dakota Subterminal Systems, Agricultural Economics Report No. 156, Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota, February 1983.
3. Chicago Board of Trade. Grains: Production, Processing, Marketing, Revised Edition, L. Besant editor, Chicago, 1982, Chapter 9.
4. Davis, Leroy and Hill, Lowell. "Spatial Price Differentials for Corn Among Illinois Country Elevators," American Journal of Agricultural Economics 66 (1974):135-144.
5. Eldridge, Chuck, Jerry Fruin, and Mike Alley. Minnesota Grain Shipments 1981, Experiment Station, University of Minnesota, St. Paul, Minnesota, May 1983.
6. Garcia, Philip. The Transmission of Market Information Among a Sample of Illinois Grain Elevators, 82 E-229, Series E, Illinois Agricultural Economics Staff Paper, Department of Agricultural Economics, University of Illinois, Urbana-Champaign, Illinois, July 1982.
7. Helmuth, J. Grain Pricing, Economic Bulletin No. 1, Commodity Futures Trading Commission, Washington, D.C., September 1977.
8. Hieronymus, T. Economics of Futures Trading: For Commercial and Personal Profit, 2nd Ed., New York: Commodity Research Bureau, 1977.
9. \_\_\_\_\_. Hedging for Country Elevators, AERR 91, University of Illinois, March 1968.
10. Kamien, M. and N. Schwartz. Market Structure and Innovation, Cambridge University Press, 1982.

11. Kennedy, Peter. A Guide to Econometrics, Cambridge, Massachusetts: MIT Press, 1979.
12. Lamberton, C.E. 1981 Grain Marketing Patterns from Southeastern South Dakota. Unpublished research report, Economics Department, South Dakota State University, Brookings, South Dakota, 1982.
13. Lamberton, C.E. Restructuring a Rail System: South Dakota's Experience from 1976-1981, Bulletin 688, Agricultural Experiment Station, South Dakota State University, Brookings, South Dakota, 1983.
14. Levins, Richard and Fruin, Jerry. Transportation Requirements for Minnesota Corn Exports, Staff Paper P80-24, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota, October 1980.
15. Pindyck, Robert S. and Rubinfeld, Daniel L. Econometric Models and Econometric Forecasts, 2nd Edition, New York: McGraw-Hill Book Company, 1981.
16. Purcell, Wayne. Agricultural Marketing, Systems, Coordination, Cash and Futures Prices, Reston, Virginia: Reston Publishing Company, Inc., 1979.
17. Riggins, Steven K. "The Pricing Efficiency of Corn in a Minor Surplus Production Area," Southern Journal of Agricultural Economics 10(1978):165-170.
18. Sogn, Arthur B. Producer Strategies When Transportation Distorts Pricing of Grain, Economic Staff Paper No. 80-2, Economics Department, South Dakota State University, Brookings, South Dakota, August 1980.
19. Thompson, Sarahelen R. and Dahl, Reynold P. The Economic Performance of the U.S. Grain Export Industry, Technical Bulletin 325-1979, Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota, 1979.